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(54) Title: BIOSENSING METER WITH AMBIENT TEMPERATURE ESTIMATION METHOD AND SYSTEM

BIOSENSING METER WITH AMBIENT TEMPERATURE ESTIMATION METHOD AND SYSTEM

FIELD OF THE INVENTION

This invention relates to biosensing meters for determining the presence of an analyte in a biological sample, such determination sensitive to ambient temperature, and more particularly, to a method and system for estimating such ambient temperature.

BACKGROUND OF THE INVENTION

Biosensing instruments are often used for the detection of various analyte levels in blood samples (e.g., glucose and cholesterol). Such instruments employ disposable sample strips with a well or reaction zone for receiving a blood sample. Analyte readings obtained from such instruments are dependent upon the ambient temperature that surrounds the sample well or reaction zone. Various prior art instruments employ external thermal sensors or make an attempt to control the temperature of the reaction zone. While external temperature sensors are capable of rapidly reacting to a temperature change, under certain circumstances that becomes a detriment rather than an attribute. For instance, if a biosensing instrument is small enough to be held in a user's hand, when that instrument is placed on a tabletop, a rapid temperature change can occur that will render invalid subsequent biochemical readings – until the ambient temperature reading has stabilized. If the biosensing instrument is

battery-driven, it becomes impractical to control
the temperature at the reaction zone as such action
requires too great a power drain from the
5   instruments battery.

The prior art includes a number of disclosures of
biosensing instruments that employ temperature
correction. In US Patent 5,108,564 to Szuminsky et
10   al, a biosensing instrument is disclosed that
measures glucose concentrations in blood.   The
instrument depends upon a reaction wherein glucose,
in the presence of an enzyme, catalyzes a reaction
of   potassium   ferricyanide   to   potassium
15   ferrocyanide. After the reaction has completed, a
voltage is applied across a reaction zone and
causes a reversal of the reaction, with an
accompanying generation of a small, but measurable
current.   That current is termed the Cottrell
20   current and, in dependence upon the concentration
of glucose in the reaction zone, follows a
predetermined curve during the reverse reaction.
By determining the position of the curve, an
indication of glucose concentration can be
25   obtained.

European Patent application 047198682 of Tsutsumi
et al discloses a blood glucose measurement system
that employs disposable sample strips.   The
30   Tsutsumi et al system detects the presence of a
blood sample by sensing a resistance across a pair
of electrodes. It further employs plurality of
sample-like strips, each having a specific
resistance value which distinguishes it from other
35   strips. Each of those strips has a particular

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application, i.e., for use during an adjustment mode of the instrument, during an error compensation mode; during a calibration mode; etc.

US Patent application, 07/451,309, filed December 15, 1989 to White and entitled "Biosensing Instrument and Method" and assigned to the same assignee as this application, teaches a biosensing instrument which employs the "Cottrell" curve relationship to determine glucose concentrations. In the White patent application, a ratio between current samples and times at which the current samples are taken is used to determine whether the current flow through a sample strip's reaction zone is, in fact, following the Cottrell relationship.

US Patent 4,420,564 to Tsuji et al. describes a blood sugar analyzer that employs a reaction cell having a fixed enzyme membrane sensor and a measuring electrode. The Tsuji et al. system includes several fail/safe procedures, one to determine that the reaction is taking place within specifically defined temperature limits and a second to determine if a reaction current remains within a predetermined range.

In the above noted prior art that indicates a need for temperature sensing, temperature values are obtained by temperature sensors and those sensed values are directly used. Variations in those sensed temperatures can create substantial variation in biochemical readings and cause erroneous outputs. Since such readings are of

vital importance to the user and, if erroneous, may
result in the mis-administration of medications, it
is vital that erroneous readings be avoided. Thus,
such biosensing instruments must include means for
5   avoiding erroneous readings that result from
erroneous ambient temperature inputs.

Accordingly, it is an object of this invention to
provide a biosensing instrument with a method and
10   means for providing accurate temperature values so
as to enable proper analyte value indications.

It is another object of this invention to provide a
biosensing instrument with a temperature sensor
15   that is resistant to rapid temperature excursions
as result of environmental changes, but still
provides accurate ambient temperature values to
enable analyte determinations.

20   SUMMARY OF THE INVENTION

A biosensing meter is provided that determines a
value of an analyte in a biological sample. The
meter employs an algorithm for determining the
25   analyte value, which value is dependent upon
ambient temperature about the biological sample
when it is present in a reaction zone. The
biosensing meter includes a processor and a
temperature sensor. The temperature sensor is
30   positioned within the meter's structure and thereby
exhibits a delayed response to changes in the
ambient temperature. The meter performs an ambient
temperature estimation method to overcome the

delayed temperature response. The method commences by the meter repetitively and periodically acquiring temperature readings from the temperature sensor when the biosensing meter is both in an on state and in an off state. When the meter is in the on state, the algorithm estimates the ambient temperature by employing at least two most recent temperature readings and extrapolating therefrom to achieve an ambient temperature estimate. Temperature readings are acquired by the meter at first intervals when the meter is in the off state and at second, shorter intervals when the meter is in the on state, the temperature extrapolations only occurring when the meter is in the on state.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a biosensing meter incorporating the invention.

Fig. 2 is a block diagram of circuitry contained within the biosensing meter of Fig. 1.

Fig. 3 is a waveform diagram illustrating both an excitation voltage applied to an excitation electrode of a disposable sample strip used with the meter of Fig. 1 and a resulting sense current determined from a sense electrode on the disposable sample strip.

Fig. 4 indicates a change in ambient temperature and a resulting change in temperature as sensed at

a temperature sensor within the meter Fig. 1.

Fig. 5 is a high level flow diagram illustrating
the procedure followed by the method of the
invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Fig. 1, a biosensing meter 10
includes a liquid crystal display 12, control
buttons 14, and a slot 16 for receiving a
disposable sample strip 18. Sample strip 18
contains a well 20 (i.e. reaction zone) that
encompasses a pair of conductive electrodes 24 and
26. A layer (not shown) of enzymatic reactants
overlays electrodes 24 and 26 in well 20 and
provides substrate on which an analyte-containing
fluid sample may be emplaced.

Disposable sample strip 18 has an opening 28 that
exposes the distal ends of electrodes 24 and 26 and
renders them available for electrical connection
within biosensing meter 10 (electrical connections
not shown in Fig. 1).

A temperature sensor 30 (shown in phantom) is
positioned within the case of biosensing meter 10
and provides continuing temperature value inputs to
a microprocessor contained within biosensing meter
10. The position of temperature sensor 30 within
biosensing meter 10 causes it to be insulated from
immediate temperature changes that occur in the
ambient about the meter's exterior. As a result,

temperature sensor 30 will respond to a change in ambient temperature, but will do so in a delayed manner and over a plurality of thermal time constants, the length of the time constant being a function of the isolation of temperature sensor 30 from the ambient.

Referring to Fig. 2, a schematic is shown of circuitry within biosensing meter 10, with a disposable sample strip 18, inserted in slot 16. An excitation voltage source 32 provides a variable voltage to a contact 34 that makes connection with electrode 24 when disposable sample strip 18 is in position within meter 10. A contact 36 enables a current from electrode 26 to be fed to a sense amplifier 38 whose output (a voltage) is, in turn, fed to an analog to digital converter (A/D) 40. Temperature sensor 30 also provides its output to an A/D converter 42. The outputs from A/D converters 40 and 42 are applied to a bus 44 which provides communications between modules contained within biosensing meter 10. A microprocessor 46, with an allied display unit 12, provides overall control of the operation of biosensing meter 10. Microprocessor 46 also has a variety of timing functions 50 contained therein whose use will become apparent from the description below.

Excitation voltage source 32 receives its commands from microprocessor 46 via bus 44, and response to those commands applies varying levels of excitation potential to electrode 24. A read only memory key 52 is pluggable into biosensing meter 10 and

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contains a non-volatile memory that includes
constants and other data required to carry out the
analyte-determination procedures required of meter
10. ROM key 52 plugs into the upper most portion

5   of meter 10 as shown in Fig. 1. In general, a ROM
key 52 will accompany each batch of disposable
sample strips 18, and will contain various
constants that will enable meter 10 to adjust its
measurement parameters to match the specific batch

10   characteristics of disposable sample strips 18.

In this example, it will be assumed that the
analyte-containing sample is a drop of blood that
is being subjected to a glucose determination. A

15   disposable sample strip for a glucose determination
will include, in well 20, the following reactants:
an enzyme, an electrolyte, a mediator, film
formers, and a buffer. For instance, the enzyme
may be glucose oxidase or glucose dehydrogenase;

20   the buffer may be organic or inorganic; the
electrolyte may be potassium chloride or sodium
chloride; the mediator is preferably potassium
ferricyanide and the film formers comprise gelatin
and propiofin. (If the test cell is to be employed

25   for a cholesterol concentration determination, the
enzyme would preferably be cholesterol oxidases,
with, or without a cholesterol esterase additive.
The buffer would be preferably inorganic and would
include an electrolyte such as potassium chloride

30   or sodium chloride. In this case two mediators
would be used, i.e. ferricyanide and quinones, and
would be placed in the gelatin film as indicated
above.)

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As the chemistry employed to make such analyte determinations are known in the art, they will not be described in significant detail. Suffice to say that a glucose determination is made by initially emplacing in well 20, a sample of blood. The glucose within the sample causes a forward reaction of potassium ferricyanide to potassium ferrocyanide. The forward reaction proceeds to completion during an incubation period. A subsequent application of an excitation voltage to an electrode in disposable sample strip 18 will see the creation of a small current at the opposite electrode that results from a reverse reaction of potassium ferrocyanide back to potassium ferricyanide. The flow of electrons during the reverse reaction is sensed and measured at a number of points so as to enable determination that the reaction is both following a Cottrell curve and to further determine the level of the Cottrell curve. That level is indicative of the glucose concentration. Any resultant glucose value, however, must be corrected to take into account the ambient temperature.

The excitation potentials supplied by excitation voltage source 32 to electrode 24 are shown by trace 60 in Fig. 3. The resulting sense current, as determined by sense amplifier 38, is shown by trace 62. Initially, excitation voltage source 32 applies a level 64 to electrode 24. When a blood sample is placed in well 20, a current pulse 66 results, indicating to microprocessor 46 to commence an incubation period. At such time, the

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excitation voltage level 64 is removed from
electrode 24 (level 68) to enable a reaction to
occur between the drop of blood and the reactants.
At the end of the incubation period, excitation
5   voltage source 32 applies a voltage level 70 to
electrode 24. In response, sense amplifier 38
detects and measures a number of currents flowing
to electrode 26 (as shown by trace 72).

10   Assuming that the current sensed across well 20 is
following the Cottrell relationship, the current
values sensed along curve 72 will be displaced
either upwardly or downwardly dependent upon the
level of glucose present in the blood sample.
15   Microprocessor 46, in conjunction with ROM key 52
employs the measurements taken along curve 72 to
determine the position of curve 72 and derives a
glucose value therefrom. In order to alter the
resultant glucose value so determined, the ambient
20   temperature must be determined and a correction
applied. Only after such correction is made, is
the glucose value displayed to the user on display
12.

25   Turning to Figs. 4 and 5, the temperature
estimation procedure employed by a biosensing meter
10 will be described. Because it is desired to
isolate temperature sensor 30 from rapid thermal
changes, temperature sensor 30 is mounted within
30   biosensing meter 10 so as to be somewhat isolated
from the ambient temperature. As a result, when an
ambient temperature change occurs, thermal sensor
30 will begin to alter its output in accordance

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therewith, but will only arrive at the actual ambient temperature after plural thermal time constants have passed. One thermal time constant for biosensing meter 10 is the time required for temperature sensor 30 to traverse approximately 60 percent of the temperature difference between the beginning temperature of thermal sensor 30 and the actual ambient temperature.

In one meter that has been constructed in accordance with this invention, the thermal time constant is approximately ten minutes. In order for temperature sensor 30 to traverse ninety-eight percent of the temperature between the beginning temperature of thermal sensor 30 and ambient, the passage of four time constants or forty minutes is required—if biosensing meter 10 is to wait for such an occurrence.

Clearly, it is not desirable for the user to wait for forty minutes to obtain an accurate glucose reading. As a result, it has been determined that accurate glucose readings can be obtained by estimating the ambient temperature from a few temperature readings from temperature sensor 30. Those readings are obtained over a short period of time, e.g., characteristically less than one minute. In order to achieve such an estimation of temperature, at least two temperature sensings must be available for calculation by microprocessor 46. One such temperature reading will hereafter be referred to as T_{old} and a later temperature reading will be referred to as T_{new}.

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So as to not require a user to wait for two temperature readings to be obtained, biosensing meter 10 is caused to take temperature readings at periodic intervals even when it is in the off state. In such off state, sufficient power is provided to microprocessor 46 that microprocessor 46 takes a temperature reading from temperature sensor 30 every three minutes. That temperature reading is stored as T_{new} while the former T_{new} replaces the previous T_{old} value stored in RAM within microprocessor 46. Clearly, those skilled in the art will realize that the time of three minutes is not critical and may be varied in accordance with the meter's requirements.

When meter 10 is subsequently powered on by the user, microprocessor 46 then obtains readings from temperature sensor 30 every thirty seconds to obtain T_{new} values. The first such T_{new} reading after a power on is combined with the T_{old} reading already stored in RAM in microprocessor 46. From those two readings, an initial extrapolation is made to determine $T_{ambient}$. Thereafter, new temperature readings T_{new} are taken and at each such time, a T_{old} value is dropped and is replaced by the previous T_{new} reading which becomes the T_{old} value. In such a manner, meter 10 is able to provide $T_{ambient}$ values very rapidly after power on and proper glucose value modifications can be made in accordance therewith.

Referring to Fig. 4, it is assumed that $T_{ambient}$ varies from level 80 to level 82. Also, it is

assumed that meter 10 is in an off state until 10
minutes have passed at which time it is turned on.
Until time t=10, temperature readings are taken
every three minutes (during the off state) and are
stored. When the meter is turned on, temperature
readings begin being taken every thirty seconds and
temperature extrapolations made after every such
reading. When $T_{ambient}$ changes from level 80 to level
82, the output 84 from temperature sensor 30 begins
to approach the new ambient temperature (level 82)
in an exponential fashion. Output temperature
reading values from temperature sensor 30, taken
during this time, enable microprocessor 46 to
render an estimation of $T_{ambient}$ in accordance with
the following relationship:

$$T_{ambient} = T_{new} + \frac{T_{new} - T_{old}}{e^{m\Delta t}-1} \qquad (A)$$

Where: m = inverse of the meter's thermal
time constant (in seconds); and
Δt = the time in seconds between
acquisition of T_{new} and T_{old}.

Referring to Fig. 5, the ambient temperature
estimation procedure employed by microprocessor 46
will be described. As indicated by decision box
100, if meter 10 is off, a determination is made
whether three minutes have elapsed since the last
temperature reading (decision box 102). If three
minutes have not elapsed, the procedure recycles.

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Upon the passage of three minutes, a new temperature reading T_{new} is taken (box 104). The old temperature reading T_{old} is replaced with the previous temperature reading T_{new} (box 106). The procedure then recycles to again determine whether meter 10 has been turned on or off.

Once meter 10 is turned on, the elapsed time Δt from the last temperature reading is determined and compared to a threshold time value obtained from memory. If the Δt value exceeds the threshold value (e.g. thirty seconds), a new temperature reading T_{new} is taken and stored with T_{old} (box 110). If the elapsed time Δt is less than the threshold time value, the procedure recycles to wait for the expiration of a proper amount of time.

The aforesaid threshold time value for Δt is employed to prevent microprocessor 46 from making extrapolations based upon temperature readings that are taken too close together in time. Such readings could cause a substantial error which would skew the temperature estimate. As can be seen from equation A, as the value of Δt decreases, the value of $e^{\Delta t}$ approaches unity. As a result, if Δt is too small the $1/(e^{m\Delta t} -1)$ factor becomes large. This factor can greatly multiply small errors in the measurement of T_{new} and T_{old} and result in an erroneous skew in the ultimate $T_{ambient}$ calculated value.

Once a new temperature reading T_{new} is taken, a portion of equation A is calculated (box 112) as

follows:

$$X1 = \frac{1}{e^{m\Delta t}-1} \qquad (B)$$

Once equation B is calculated, it is determined whether the new sensed temperature T_{new} minus the old temperature T_{old} is less than a temperature threshold value ΔT (decision box 114). Threshold value ΔT is obtained from ROM key 52. In the case where both T_{new} and T_{old} are very close, it is possible that the estimation algorithm can actually show a significant movement in temperature when, in fact, the difference could entirely be due to noise. Therefore, the difference between T_{new} and T_{old} is compared to a temperature estimation threshold ΔT obtained from ROM key 52. If the temperature difference is greater than the ΔT threshold value, then a full temperature estimation is warranted. If, however, the difference between the temperature samples is less than the ΔT value obtained from ROM key 52, the temperature samples are assumed to be essentially identical and no temperature movement is assumed to have been seen during the entire Δt (indicating that meter 10 is probably at equilibrium). Therefore, no estimation is needed and T_{new} may be used as the new ambient temperature

If, by contrast, the temperature difference between T_{new} and T_{old} is equal to or exceeds the ΔT threshold value, equation (C) is calculated as shown in box 118:

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$$T_{ambient} = T_{new} + [(T_{new} - T_{old})X1] \qquad (C)$$

5   Equation (C) allows a new $T_{ambient}$ estimate to be
obtained. The previously stored value of $T_{ambient}$ is
then updated with the new value (box 120). The new
value $T_{ambient}$ is then compared with operating limit
values obtained from ROM key 52 (decision box 122).
10   If $T_{ambient}$ is not within proper operating limits, the
test is aborted (box 124). If $T_{ambient}$ is found to be
within proper operating limits, then $T_{ambient}$ is
employed to compensate the glucose reading value
(box 126). Such operating limit values are the
15   limits of the temperature correction algorithm,
(e.g., between 18°C and 32°C).

It should be understood that the foregoing
description is only illustrative of the invention.
20   Various alternatives and modifications can be
devised by those skilled in the art without
departing from the invention. For example, while
two A/D converters 40 and 42 are shown in Fig. 2, a
single A/D converter for both inputs will operate
25   equally well. Accordingly, the present invention
is intended to embrace all such alternatives,
modifications and variances which fall within the
scope of the appended claims.

CLAIMS

1.   In a biosensing meter for determining a value of an analyte in a biological sample, a determined analyte value dependent upon an ambient temperature about said biological sample, said biosensing meter including a processor and a temperature sensor, said temperature sensor positioned within said meter and thereby exhibiting a delayed response to changes in said ambient temperature, said meter performing a temperature estimation method under control of said processor so as to overcome said delayed response, said method comprising the steps of:

(a). periodically acquiring temperature readings from said temperature sensor when said biosensing meter is both in an ON state and in an OFF state; and

(b) when said biosensing meter is in said ON state, estimating said ambient temperature by employing at least two most recent temperature readings.

2. The method as recited in claim 1 wherein step b estimates said ambient temperature by using said two most recent temperature readings and extrapolating therefrom to determine said estimate of said ambient temperature.

3. The method as recited in claim 2 wherein said temperature readings are acquired at first

intervals when said meter is in said OFF state, and at second, shorter intervals when said meter is in said ON state, said biosensing meter employing a temperature reading acquired when said meter is in said OFF state and a temperature reading when said meter is in said ON state to determine at least one said temperature estimate.

4. The method as recited in claim 1 wherein said estimation step is only performed if a difference between said two most recent temperature readings exceeds a threshold value, a latest temperature reading being employed as said ambient temperature if said threshold value is not exceeded.

5. The method as recited in claim 1 wherein said estimation step extrapolates said two most recent temperature readings T_{old} and T_{new} to obtain $T_{ambient}$ by employing the expression:

$$T_{ambient} = T_{new} + \frac{(T_{new} - T_{old})}{e^{m\Delta t} - 1}$$

Where: m = inverse of the meter's thermal time constant (in seconds);
Δt = the time in seconds between acquisition of T_{new} and T_{old}.

6. The method as recited in claim 5 wherein if T_{old} is acquired when said meter is in said OFF state, and said meter is switched to the ON state and a T_{new} reading is acquired, the method comprising the added steps of:

determining an elapsed time between when T_{old} and T_{new} values are acquired;

comparing said determined elapsed time against a time threshold; and

disregarding said T_{new} reading if said elapsed time is not at least equal to said elapsed time threshold.

7. The method as recited in claim 5, comprising the following added steps of:

finding a temperature difference value between T_{new} and T_{old};

comparing said temperature difference value with a temperature difference threshold value; and

employing T_{new} reading as a new $T_{ambient}$ value if said temperature difference value is less than said temperature difference threshold value, based upon an assumption that said biosensing meter is at a stable temperature.

8.   The method as recited in claim 7 wherein
said biosensing meter includes a pluggable read
only memory chip, and wherein said temperature
difference threshold value is acquired from said
pluggable read only memory chip.

9.   The method as recited in claim 5, wherein
said biosensing meter is enabled to operate only if
said $T_{ambient}$ falls within preestablished operating
temperature limits.

FIG. 1.
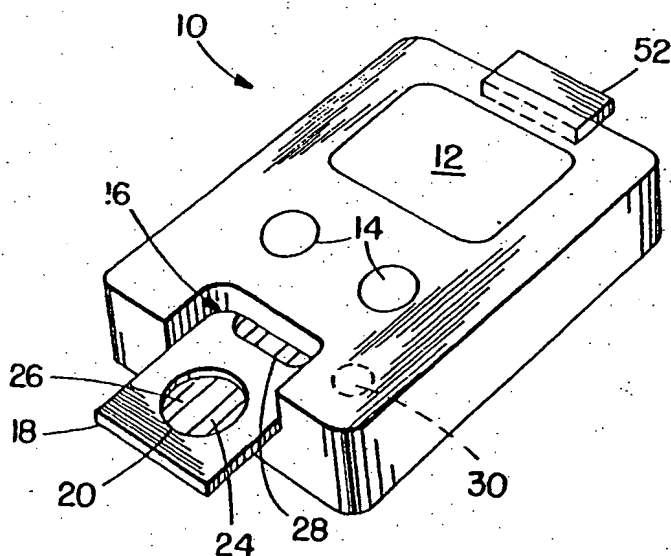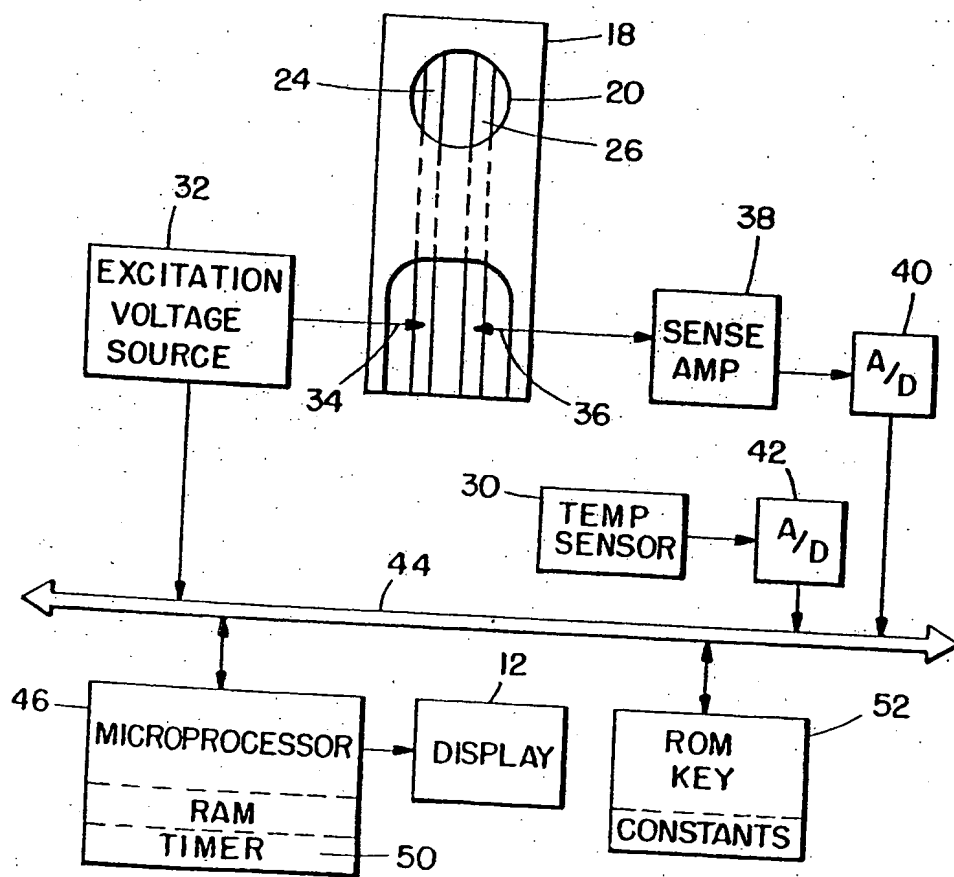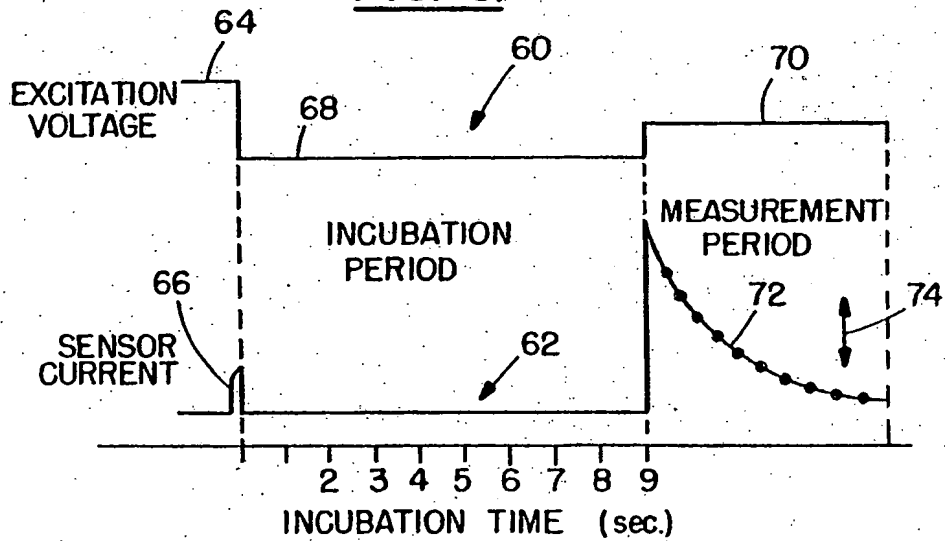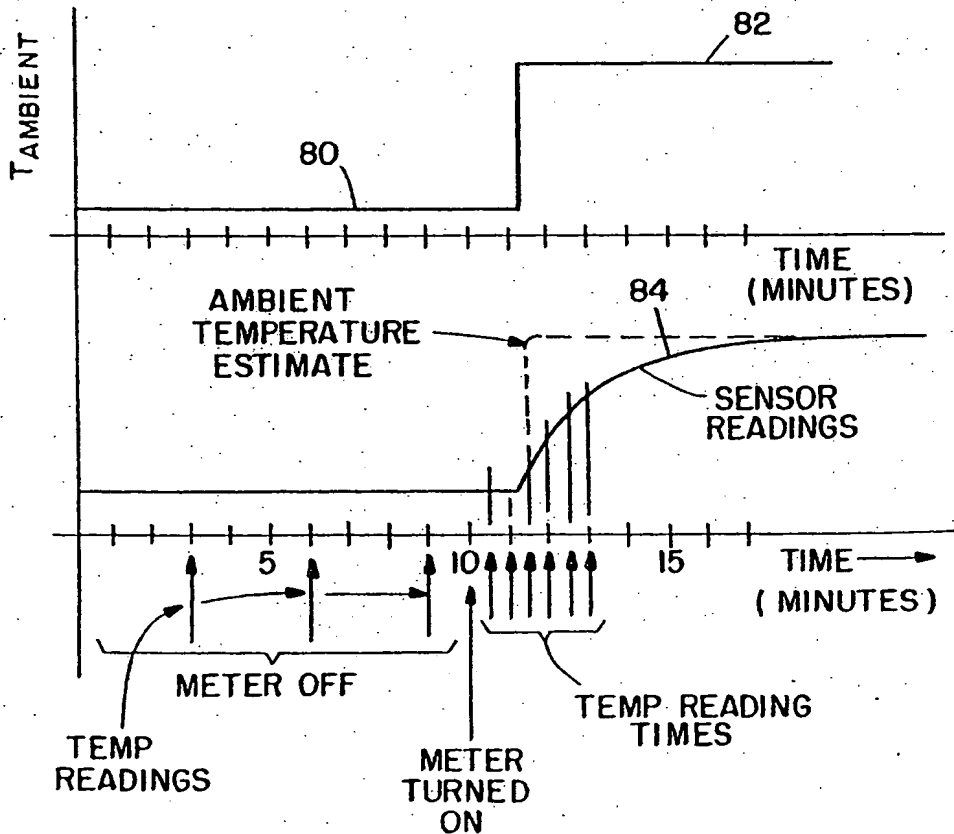

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

100 — METER ON OR OFF ?

OFF →   ON →

102 — 3 MIN ELAPSED SINCE LAST TEMP READING ? → NO

YES ↓

104 — TAKE NEW TEMP READING T NEW AND STORE

↓

106 — REPLACE OLD TEMP READING TOLD WITH PREVIOUS TEMP TNEW

108 — ELAPSED TIME Δt FROM LAST TEMP. READING ≥ THRESHOLD ? (e.g 30 sec.) → NO

YES ↓

110 — TAKE NEW TEMP (TNEW) READING & STORE WITH OLD TEMP (TOLD)

↓

112 — CALCULATE $XI = \dfrac{1}{e^{M\Delta t} - 1}$

M = RECIPROCAL OF THERMAL TIME CONSTANT

↓

114 — TNEW – TOLD < ΔT THRESHOLD

YES → **116** — USE TNEW AS NEW TAMBIENT

NO ↓

118 — CALCULATE TNEW + [(TNEW–TOLD) × I] TO OBTAIN NEW TAMBIENT

↓

120 — UPDATE TAMBIENT

↓

122 — IS TAMBIENT WITHIN OPERAT-ING LIMITS ?

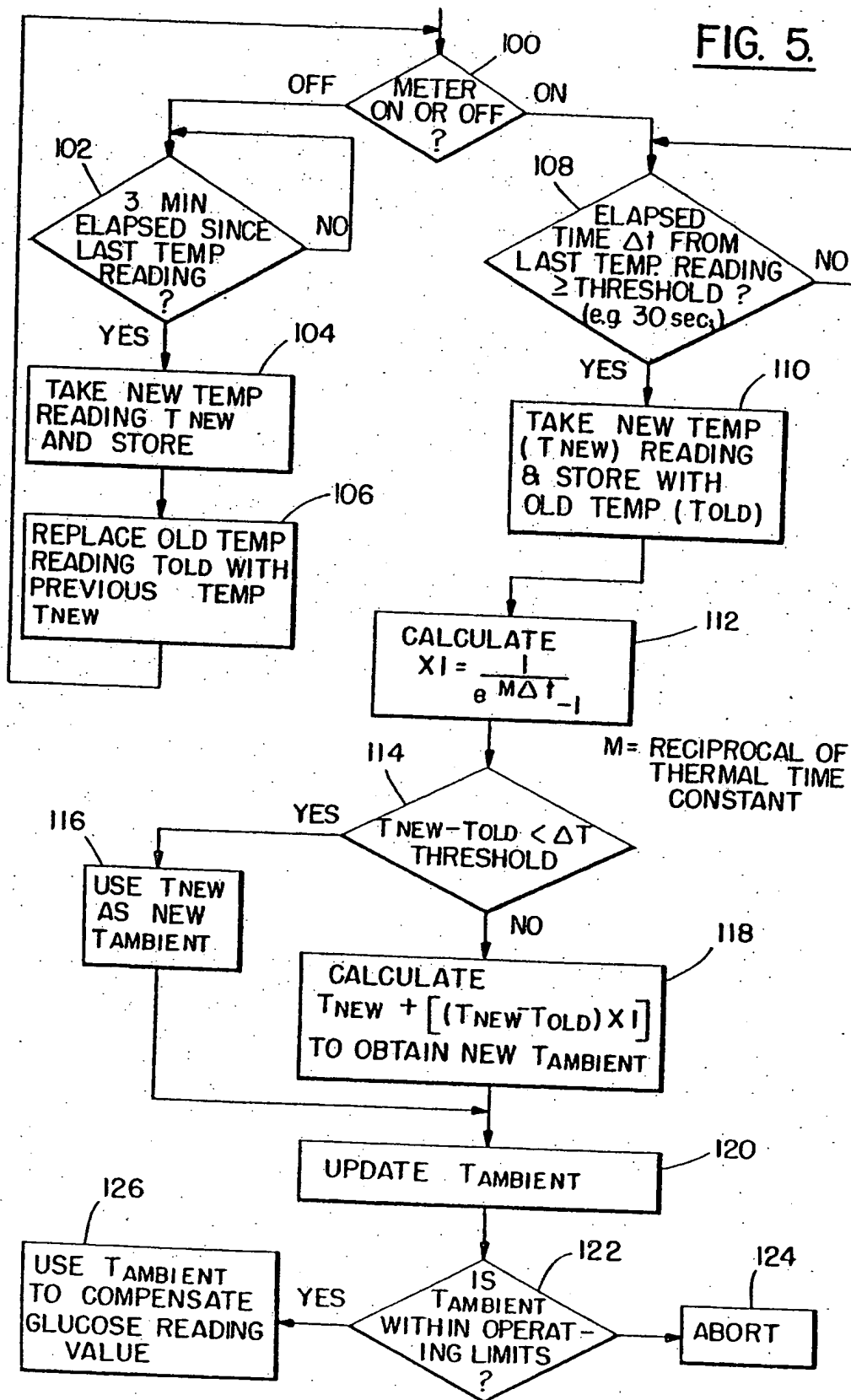YES → **126** — USE TAMBIENT TO COMPENSATE GLUCOSE READING VALUE

→ **124** — ABORT

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PATENT COOPERATION TREAT

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT
(PCT Article 17(2)(a) and Rule 39)

Applicant's or agent's file reference 358-924215-P	IMPORTANT DECLARATION	Date of mailing (day/month/year) **JUL 13 1994**
International application No. PCT/US94/05321	International filing date (day/month/year) 13 MAY 1994	(Earliest) Priority Date (day/month/year) 08 JUNE 1993

International Patent Classification (IPC) or both national classification and IPC
Please See Continuation Sheet.

Applicant

BOEHRINGER MANNHEIM CORPORATION

This International Searching Authority hereby declares, according to Article 17(2)(a), that no international search report will be established on the international application for the reasons indicated below.
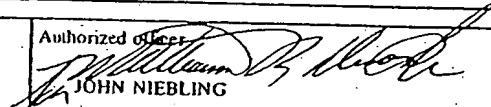
1. [X] The subject matter of the international application relates to:

    a. [ ] scientific theories.

    b. [X] mathematical theories.

    c. [ ] plant varieties.

    d. [ ] animal varieties.

    e. [ ] essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes.

    f. [ ] schemes, rules or methods of doing business.

    g. [ ] schemes, rules or methods of performing purely mental acts.

    h. [ ] schemes, rules or methods of playing games.

    i. [ ] methods for treatment of the human body by surgery or therapy.

    j. [ ] methods for treatment of the animal body by surgery or therapy.

    k. [ ] diagnostic methods practiced on the human or animal body.

    l. [ ] mere presentations of information.

    m. [ ] computer programs for which this International Searching Authority is not equipped to search prior art.

2. [X] The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:

    [ ] the description   [X] the claims   [ ] the drawings

3. [ ] The failure of the nucleotide and/or amino acid sequence listing to comply with the prescribed requirements prevents a meaningful search from being carried out:

    [ ] it does not comply with the prescribed standard

    [ ] it is not in the prescribed machine readable form

4. Further comments:

The manipulative steps of determining a value of an analyte were not given in the claims as recited. It was not certain as to what should be done with the algorithm to determine the analyte value.

Name and mailing address of the ISA/US.
 	
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Form PCT/ISA/203 (July 1992)*

DECLARATION C NON-ESTABLISHMENT OF
INTERNATIONAL SEARCH REPORT

The International Patent Classification (IPC) or National Classification and IPC are as listed below:

IPC(5): G01N 27/26
US CL: 204/403, 406